

EXECUTIVE SUMMARY

The King County Department of Natural Resources and Parks operates and maintains three wastewater treatment plants (West Point, South Plant, and Vashon Island) and two combined sewer overflow treatment plants (Alki and Carkeek) that discharge treated effluent into the Central Puget Sound Basin. King County has a marine monitoring program to confirm that these discharges are not degrading water quality within the vicinity of the treatment plants. The routine marine monitoring program has two components: point source monitoring focusing on areas near treatment plant discharges and ambient monitoring focusing on areas outside the immediate vicinity of treatment plant discharges. Monitoring areas outside the influence of point source discharges is necessary in order to assess background conditions in central Puget Sound.

King County is plans to build a new regional wastewater treatment plant that will discharge treated effluent through a marine outfall in northern King County or southern Snohomish County. An intensive marine monitoring program, the Marine Outfall Siting Study (MOSS), was initiated in late 1998 to support siting a suitable outfall location. The MOSS project continued throughout 2001 and data collected in 2001 are presented in this report.

In 2001, 6 offshore/nearshore and 5 beach water stations, 19 offshore/nearshore and 3 beach sediment stations, 4 shellfish stations, and 4 macroalgae stations were sampled for the point source program. For the ambient program, 6 offshore/nearshore and 15 beach water stations, 3 beach sediment stations, 6 shellfish stations, and 5 macroalgae stations were sampled. Water samples were analyzed for bacteria, nutrients, dissolved oxygen, chlorophyll, and physical parameters. Sediment samples were analyzed for organic compounds, metals, and conventional parameters. Six sediment samples around the South Plant wastewater treatment plant were also sampled for benthic fauna. Shellfish samples were analyzed for organics, metals, and bacteria. Macroalgae were analyzed for metals.

In 2001, 22 stations were sampled for the MOSS project. Six of these stations are also sampled for the ambient monitoring program and two for the point source monitoring program, however, additional parameters that are not part of the routine sampling program were included for the MOSS project. Ten offshore water stations were sampled for physical properties, nutrients, dissolved oxygen, chlorophyll, and bacteria for the MOSS project. Twelve beach stations were also sampled for the MOSS project in 2001. Beach waters were sampled for physical properties, nutrients, bacteria, and total and dissolved metals. In addition, organics (including polynuclear aromatic hydrocarbons, chlorinated and organophosphorus pesticides, polychlorinated biphenyls, and chlorinated herbicides) were sampled at three stations.

Water quality data were also collected for the MOSS project in a series of transects at five locations in the Central Basin. Each transect consisted of either five or six stations spaced equidistant across the length of the transect. Measurements were recorded monthly starting in 2000 and continued for six months in 2001. Data collected included physical properties, dissolved oxygen, and chlorophyll.

MONITORING RESULTS

Water

All offshore/nearshore stations met Washington State Class AA marine surface water standards for fecal coliform bacteria with the exception of three stations located in inner Elliott Bay. Levels at two of the three stations met the geometric mean standard of 14 colonies/100 milliliters but exceeded the peak standard of 43 colonies/100 ml. The other station exceeded both standards. The highest values for the Elliott Bay stations occurred during periods of high rainfall as these sites receive higher freshwater input than other stations due to their proximity to the Duwamish River. Fecal coliform bacteria in the water column near the County's treatment plant discharges were at low levels (usually less than 5 colonies/100 ml), if detected at all.

Fecal coliform counts at beaches are influenced by freshwater runoff from the surrounding watersheds. As a result, exceedences of Class AA marine water quality standards at some stations occurred during high rainfall months and at stations closer to freshwater sources. Ten beaches exceeded both the geometric mean and peak standards; four met the geometric mean but not the peak standard; and fourteen passed both standards. Beaches with the lowest bacteria counts were located near Boeing Creek, Seacrest Park and around the Duwamish Head area. Highest counts were at Brackett's Landing, Fauntleroy Cove, and the south side of Alki Point.

Enterococcus bacteria levels in the offshore/nearshore water column were either not detected or were low. Enterococcus bacteria counts at beach stations varied between stations and months and did not correlate with fecal coliform bacteria counts. *E. coli* was monitored at the MOSS stations only and showed the same pattern as enterococcus bacteria, in that *E. coli* was seldom detected in offshore waters and varied between stations and months. There was a clear correlation between *E. coli* and fecal coliform count but not enterococcus bacteria.

Temperature, salinity, and density values indicated a well-mixed water column throughout most of the year, although seasonal thermal stratification was evident in the summer. A time-lag of about one month was noted in the peak water temperatures between beach and offshore stations with temperatures peaking in June at offshore stations and in July for most beach stations. In 2001, all dissolved oxygen (DO) values were above 5.0 mg/L, which is an indicator level at which potential problems could occur.

Nutrients, such as ammonia and nitrate+nitrite, exhibited trends similar to previous years. Ammonia was highest in the summer and nitrate+nitrite was most abundant in winter when not being taken up by phytoplankton. All ammonia concentrations for beach and offshore stations, including those located near the treatment plant outfalls, were well below the Washington State ammonia criterion for marine surface waters.

Total and dissolved metals were analyzed at the MOSS beach stations and dissolved metals were analyzed at seven ambient and point source beach stations. For total metals, 12 of the 15 elements analyzed were detected in all samples. For dissolved metals, 10 of the 15 elements were detected in all samples. For copper, a constituent in marine boat paints as well as effluent and stormwater, the highest concentrations were found at stations with heavy boat traffic, such as near the Shilshole Bay Marina. Metal concentrations at all beach stations were below Washington State acute and chronic marine water quality criteria.

A total of 107 organic compounds were analyzed in beach waters from three MOSS sites: 64 semi-volatiles, 26 chlorinated pesticides/polychlorinated biphenyls (PCBs), 10 chlorinated herbicides, and 7 organophosphorus pesticides. Chlorinated pesticides, herbicides, PCBs, and organophosphorus pesticides were not detected in any of the samples. A total of 10 different semi-volatile organic compounds were detected in one or more samples at concentrations near the reporting limits. There are few Washington State water quality criteria for organic compounds and none of the compounds for which criteria exist were detected..

Sediment

Sediments from 13 stations around the South Plant and 6 stations around the Alki treatment plant outfalls were sampled between late October to early November 2001. Beach sediments were collected from six locations: three point source and three ambient.

Metals were analyzed in all sediments and many were either not detected (antimony, selenium, silver, and thallium) or seldom detected (cadmium). No concentrations exceeded Washington State Sediment Quality Standards (SQS) guidelines. For the outfall stations, a concentration gradient was not evident for either of the sites with respect to distance away from the outfall pipe.

Of the 98 organic compounds analyzed, 17 were detected in samples around the South Plant and Alki TP outfalls and 18 compounds were detected in beach sediments. Most of these compounds were polynuclear aromatic hydrocarbons (PAHs). Two PCB Aroclors were detected at two stations around the South Plant TP outfall (Aroclor 1254 and 1260). No organic compounds exceeded SQS criteria for either outfall or beach stations.

Biological monitoring (benthic community analysis) was conducted at six stations around the South Plant outfall in November 2001. Diversity indices and total species numbers were typical for sediments composed mostly of silt and clay, such as those around the South Plant outfall. Numerically dominant species found at all the stations are those species that are typically seen in other areas with similar sediment grain sizes and indicative of deep water silt/clay sediments. Diversity indices, species abundance, and dominant species present did not show a gradient with respect to distance away from the outfall pipe.

Shellfish

Shellfish (butter clams) tissues from four point source and two ambient stations were analyzed in July for metals and organic compounds. Thirteen of the 14 metals analyzed in 2001 were detected and concentrations varied only slightly between stations. There was no correlation between metal concentrations and lipid content. State and federal criteria do not exist for acceptable levels of metals in shellfish tissues, however, the Food and Drug Administration (FDA) has established an Action Level in fish and shellfish tissues of 1.0 mg/kg for mercury. When this value is exceeded, the food product cannot be commercially traded. Mercury concentrations in shellfish tissues were well below this Action Level. The FDA has also established guidance values termed "Levels of Concern" for shellfish for five metals: arsenic, cadmium, chromium, lead, and nickel. Shellfish tissue concentrations were below these Levels of Concern.

Of all the organic compounds analyzed, only benzoic acid and bis(2-ethylhexyl)phthalate were detected. Benzoic acid is a degradation product of metabolic processes and is always detected in shellfish samples. Quality control validation indicated the reported values of bis(2-ethylhexyl)phthalate are likely due to laboratory contamination. It is difficult to avoid laboratory contamination when processing shellfish samples as phthalates are a component in latex/nitrile gloves used in the laboratory.

Fecal coliform bacteria were analyzed in clams from six ambient stations and three point source stations monthly from May through September. Concentrations varied from station to station and from month to month. Generally, stations near Seahurst, West Point, Richmond Beach, and Normandy Park had the lowest values and the station at Carkeek Park had the highest values. The association between fecal coliform concentrations measured in shellfish and concentrations detected in water was examined and a consistent relationship was not evident. Enterococcus concentrations also varied from station to station and month to month and stations near Seahurst and West Point had consistently low values whereas Tramp Harbor had the highest values.

Macroalgae

Macroalgae (algae) samples were collected from eight beaches in 2001 (four point source and four ambient). Samples consisted entirely of the edible algae, *Ulva fenestrata* (known as sea lettuce), and were analyzed for 14 metals. Two metals (selenium and mercury) were not detected in any samples and two (beryllium and silver) were detected in one sample. The remaining 10 metals were detected in all samples. The southern West Point and Normandy Park stations had the highest concentrations of arsenic, chromium, copper, lead, nickel, and zinc and the Richmond Beach station had the lowest concentrations for most metals. Concentrations were similar to previous results with the exception of a higher copper value from the Normandy Park station.

CTD Transect Data

Conductivity, temperature, depth (CTD) transects were conducted monthly at five locations for the MOSS project between January and July. Data collected included physical properties, dissolved oxygen, and fluorescence (as an estimate of chlorophyll-*a*). Temperature, salinity, and density data indicated typical seasonal patterns, with the water column warming in June. Salinities near the surface of the Possession Sound transect were lower than other areas due to the freshwater input of the Snohomish River. Chlorophyll-*a* concentrations showed patterns similar to the northern ambient stations monitored. Dissolved oxygen concentrations were below 5.0 mg/L for the Possession Sound and Edmonds transects, although the majority of low values were recorded in Possession Sound which historically has low DO concentrations. All DO values for the other three transects were above 5.0 mg/L.